CAPSTONE TURBINE CORPORATION

HEAT RECOVERY MODULE (HRM)

USER'S MANUAL

FOR C200 MICROTURBINE

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NOTES

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ABOUT THIS DOCUMENT

This document contains user instructions for the operation and maintenance of the Heat Recovery Module (HRM) used with the Capstone C200 MicroTurbine.

This document is intended for user personnel who may not have specific training on the MicroTurbine. Any required maintenance must be performed by Capstone Authorized Service Providers (ASPs), who have received rigorous training and have been certified to perform commissioning, troubleshooting, and repair of the MicroTurbine and related systems.

User personnel who have not received certification of satisfactory completion of this training should not attempt any procedures other than those specifically described in this document.

SYMBOLS

There are three very important symbols used in this document: Warnings, Cautions, and Notes. Warnings and Cautions alert you to situations and procedures that can be dangerous to people and/or cause equipment damage. Notes provide additional information relating to a specific operation or task.

WARNING	A WARNING means that personal injury or death is possible.

CAUTION	A CAUTION means that damage to the equipment is possible.

NOTE	A NOTE clarifies instructions or highlights information that might be overlooked.

SAFETY INFORMATION

This section presents safety information for the user of C200 HRM. The user must read and understand this manual, as well as the Capstone C200 MicroTurbine™ User's Manual 400008, before operation of the equipment. Failure to obey all safety precautions and general instructions may cause personal injury and/or damage to the equipment.

It is the user's responsibility to read and obey all safety procedures and to become familiar with these procedures and how to safely operate this equipment.

Only Capstone ASPs should open the HRM enclosure due to the inherent danger of multiple power sources, high temperatures, and MicroTurbine exhaust.

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General Precautions

The following general precautions must be observed and followed at all times. Failure to do so may result in personal injury and/or equipment damage.

NOTE	Some of the following precautions do not directly apply to users, but it is important for users to be aware of them.

- **Only Capstone ASPs are permitted access to the inside of the enclosure.**
- Read and understand the User's Manual before operating the equipment.
- Read and obey all warnings and cautions.
- Make sure all exhaust and liquid connections are tight, free from leaks, and protected from damage.
- Make sure all electrical connections are tight, clean, dry, and protected from weather and damage.
- Use caution around relief valves where hot water and steam may be present.
- Use hearing protection when you work on or near a MicroTurbine that is in operation.
- The HRM is heavy. Be careful when you move or lift the HRM.
- Keep the equipment clean.
- Keep all flammable materials away from the HRM and its components.
- Do not operate or work on the equipment if mentally or physically impaired, or after consumption of alcohol or drugs.
- Make sure all fasteners are installed and properly tightened.
- Keep an ABC rated fire extinguisher near the HRM.
- Obey all applicable local, state, and national codes and regulations.

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Electrical Precautions

WARNING	The HRM is connected to high voltage. High voltage can injure or kill. Obey all safety procedures when you work around electrical equipment.

WARNING	Make sure the system is off and the dedicated disconnect switch is in the open position and is locked. This will help prevent injury and damage to the equipment.

NOTE	Some of the following precautions do not directly apply to users, but it is important for users to be aware of them.

Use caution when you work on electrical equipment. Make sure to turn off the system and lock out all sources of power prior to doing any work on the equipment. The C200 MicroTurbine is the source of electrical power for the HRM. Make sure that the MicroTurbine is off and disconnected from all electrical power before you work on the HRM. Follow the guidelines given below when working on the HRM.

- Command the MicroTurbine system to OFF.
- Open and lock the dedicated disconnect switch to isolate the MicroTurbine from the electric utility grid or loads.
- If the MicroTurbine is equipped with battery packs (i.e., if the MicroTurbine includes the Stand Alone Option), open the battery isolation switches and unplug the battery cables. Refer to the C200 MicroTurbine User's Manual (400008) for instructions.
- Wait five (5) minutes for any capacitive stored voltage to dissipate.
- Use a voltmeter to make sure that all circuits are de-energized.
- All output connections must be made in accordance with applicable codes.

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Exhaust Precautions

WARNING	Hot surfaces and hot exhaust can be dangerous. Personal injury and/or damage to equipment are possible. Take appropriate precautions when working on the equipment.

WARNING	The exhaust airflow and pipes are hot enough to cause personal injury or fire. The exhaust flow can reach temperatures as high as 371 °C (700 °F). Keep people, equipment, and other items away from the exhaust airflow and pipes. Always vent exhaust away from personnel.

WARNING	MicroTurbine exhaust contains oxides of nitrogen and carbon monoxide, which are poisonous at high concentrations. Make sure there is satisfactory ventilation when you work around the equipment.

Exhaust from the HRM (MicroTurbine exhaust) is clean and oxygen rich, with very low levels of air pollutants. Like all fossil fuel combustion technology, the MicroTurbine produces oxides of nitrogen (NOx) and carbon monoxide (CO) emissions from the fuel combustion process. Although the MicroTurbine has ultra low NOx and CO emission levels, make sure precautions are taken to prevent personnel from being exposed to these pollutants while the system is operating.

When installed indoors, the HRM exhaust must be vented to the outside. Make sure that there is satisfactory fresh air ventilation. Exhaust must be pulled away from the HRM/MicroTurbine area to reduce the risk of exposure to dangerous pollutants.

For exhaust connection data, temperatures, pipe requirements, and other related information, contact your Capstone ASP or distributor.

When installed outdoors, the HRM should be located where there is satisfactory fresh airflow so the exhaust emissions will be dissipated.

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Hot Liquid Precautions

WARNING	The temperature of the water that flows through the HRM can approach 100 °C (212 °F).The pipes and external surfaces on the HRM can be hot enough to cause personal injury.

WARNING	If liquid is introduced into a hot HRM exchanger, injury to personnel and severe damage to the HRM can result. Make sure that the heat exchanger is at ambient temperature before pumping liquid into the HRM.

WARNING	If liquid flow to the HRM ceases during operation, it is possible to create steam within the unit. The steam can be released suddenly and without warning from a pressure relief vent.

WARNING	The hot water pressure relief valve can activate suddenly and without warning if the water pressure exceeds 150 psig (1034 kPa).

Make sure that proper insulation is installed where needed on pipes that transmit hot liquid. Keep people, equipment, and other items away from the HRM during operation. Refer to the C200 HRM Technical Reference (410070) for HRM installation guidelines.

CERTIFICATIONS, PERMITS, AND CODES

The C200 HRM is designed and manufactured in accordance with a variety of national and international standards. Installations may require one or more permits from local regulatory agencies. It is not practical to list in the User's Manual the requirements of each authority having jurisdiction and how the C200 HRM meets those requirements. For certification data, such as weights, dimensions, required clearances, acoustic emission levels, and the C200 HRM Compliance List, please contact your Capstone ASP or distributor.

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REFERENCE DOCUMENTS

The following Capstone documents are referenced in this User's Manual:

- ❑ 400008 C200 MicroTurbine User's Manual
- ❑ 410070 C200 HRM Technical Reference
- ❑ 410013 Capstone Remote Monitoring System (User Edition) Technical Reference

DOCUMENT OVERVIEW

This document gives the user the data necessary to operate and maintain the C200 Heat Recovery Module (HRM). Basic troubleshooting is included in this manual, but only Capstone Authorized Service Providers (ASPs) are permitted to perform detailed troubleshooting and repair of the equipment. For detailed technical data, or for service to the MicroTurbine, contact your Capstone ASP.

C200 HRM DESCRIPTION

The C200 HRM operates with the C200 MicroTurbine to provide hot water heat recovery. The heat recovery system is based on a CAIN Industries Heat Recovery Silencer Radial (HRSR) exhaust economizer with integral temperature setpoint controller and exhaust diverter. The controller provides a digital readout of the temperature of water leaving the heat exchanger, and it allows the user to set the desired outlet temperature. An electrically operated exhaust gas diverter valve is actuated by the controller to maintain outlet temperature at the selected setpoint. Power for the controller and actuator can be supplied by the auxiliary electrical output of the C200 MicroTurbine, which is 400 to 480 Vac, depending on configuration.

Key Components

The key electrical and mechanical components that make up the C200 HRM are shown in Figure 1.

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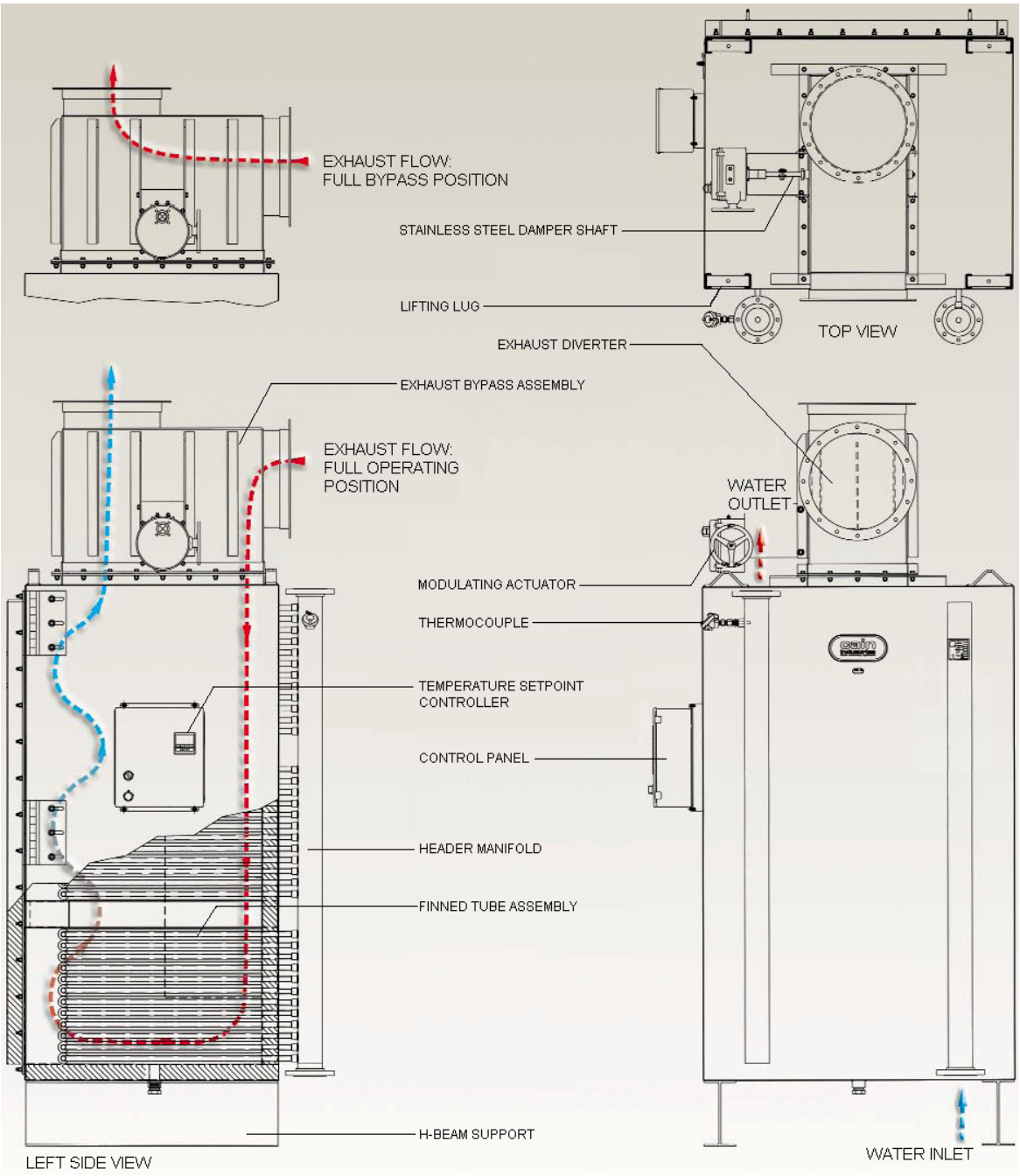

Figure 1. C200 HRM Key Components

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Main Features

The various features of the C200 HRM are described in the following paragraphs.

Heat Recovery

The C200 HRM transfers heat from the MicroTurbine exhaust to water that flows through the HRM. Water is pumped into the header manifold inlet, flows through finned tube assemblies in the enclosure of the HRM, and exits at the header manifold outlet. A thermocouple installed in the manifold tube at the outlet is used to monitor the temperature of the water as it leaves the HRM.

Exhaust from the MicroTurbine enters and exits the HRM at the exhaust bypass assembly. The exhaust moves around the finned tube assemblies to transfer heat to the water that flows through the tube assemblies. The exhaust then leaves the HRM at a cooler temperature. The exhaust diverter valve, controlled by the modulating actuator, determines the actual amount of exhaust that enters the HRM from the exhaust bypass assembly. Heat transfer is modulated within a range determined by the operational range of the bypass assembly between the full bypass and full operating positions.

When the exhaust diverter is in the full bypass position, the least amount of exhaust that enters the bypass assembly goes into the HRM, and it leaves the HRM with the least amount of its heat transferred to the water. As the exhaust diverter moves toward the full operating position, however, more exhaust is directed into the HRM. The exhaust diverter is not able to completely bypass exhaust energy due to both a small amount of exhaust leakage as well as conduction from the exhaust duct. Minimum heat recovery is 6 kW (20,000 BTU/hr).

Temperature Control and Monitoring

The C200 HRM maintains the temperature of the water at the HRM outlet based on a user-defined setpoint. An operator uses the temperature setpoint controller on the HRM control panel to enter the setpoint value. The thermocouple installed on the water outlet tube converts the water temperature to an electrical signal that is read by the controller. The controller continually compares the value of the signal from the thermocouple with the value of the setpoint. At the command of the controller, the modulating actuator moves the exhaust diverter to reduce or increase the flow of exhaust through the HRM. This moves the water temperature up or down as needed to match the value of the setpoint.

The temperature of the water at the outlet tube, as measured by the thermocouple, is stored in the Process Variable, which is shown on the upper display of the temperature setpoint controller. The operator can use this display to verify that the water temperature is at the desired level.

Exhaust Noise Reduction

The C200 HRM is designed to reduce turbine noise that comes through the exhaust. During operation, the radial design of the HRM channels the exhaust through an hour glass expansion flow pattern. This lowers the dBA levels of the noise emitted through the exhaust portals when the HRM is in heat recovery mode.

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OPERATING THE C200 HRM

Typical operation of the C200 HRM involves the use of the HRM control panel and the temperature setpoint controller to operate the water temperature control system. The following paragraphs describe the operating procedures.

C200 HRM Control Panel

Figure 2 shows the components on the control panel of the HRM. Turn the On/Off switch to ON to apply power to the water temperature control system. This supplies power to the temperature setpoint controller, the modulating actuator, and the thermocouple. Turn the On/Off switch to OFF to remove power from the system. The lamp of the POWER ON indicator comes on when power is applied and goes off when power is removed. Use the temperature setpoint controller to enter the water temperature setpoint and to monitor the temperature of the water as it leaves the HRM.

Figure 2. C200 HRM Control Panel

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Using the Temperature Setpoint Controller

The temperature setpoint controller lets the HRM operator enter the water temperature setpoint and monitor the outlet water temperature. The instructions to use the controller are contained in the following paragraphs.

Display Indicators and Controls

Refer to Figure 3 for a view of the controller. The top half of the controller contains the display where indicators and alarms are shown. The bottom half of the controller contains the input controls, which consist of buttons and an infrared transceiver. Refer to Table 1 for a description of the display indicators, and to Table 2 for a description of the input controls. Some indicators and controls that are not specific to the C200 HRM application are not discussed in this manual. Refer to the UDC2500 Universal Digital Controller Product Manual (51-52-25-127, available from http://hpsweb.honeywell.com/Cultures/en-US/Products), for more information.

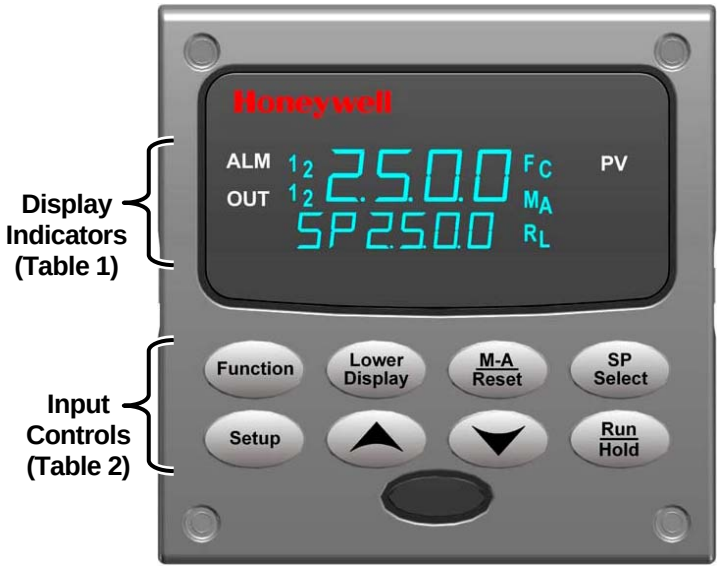

Figure 3. C200 HRM Temperature Setpoint Controller

Table 1. Controller Display Indicators

Display Indicator	Description
2500	Upper Display with four digits. Shows the Process Variable (PV) value, which is the outlet water temperature.
SP 2500	Lower Display with six characters. Shows the value of the setpoint.
ALM 1 2	Indicates Alarm 1 and/or Alarm 2 conditions exist. Only Alarm 2 is used on the C200 HRM.
F C	Indicates whether the value of the Process Variable is expressed in degrees Fahrenheit or Celsius.
M A	Indicates manual or automatic mode. Make sure that the display indicates automatic mode.

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Table 2. Controller Input Controls

Control	Description
	The **Function** button selects a function, such as Temperature Units (UNITS), during setup operations.
	The **Setup** button sequentially displays setup groups, such as the Display (DISPLY) Group, used to select Fahrenheit or Celsius for the temperature display.
	The **Lower Display** button is used to show the setpoint value on the screen, if necessary. It can also be pressed to save changes made during Temperature Display Setup and Setpoint Editing.
	The **Up Arrow** button used to increase values or cycle through selections on the display.
	The **Down Arrow** button used to decrease values or cycle through selections on the display.
	The **M-A Reset** button is used as a toggle between manual and automatic modes. The HRM is preprogrammed to operate in automatic mode. DO NOT change this setting. Changing to manual mode causes the exhaust diverter to remain in its last position, and the controller to wait for manual input to operate the diverter.

Operating the Controller

The temperature setpoint controller is the user interface for the temperature control function of the HRM. The controller automatically adjusts the temperature control mechanism on the HRM to increase or decrease the water temperature to match the value of the setpoint entered by the user. In addition, the controller is used to monitor water temperature, alarms, and the status of the controller.

Using the controller, the user can edit the water temperature setpoint, as well as set up the display to show the water temperature in degrees Fahrenheit or Celsius. Refer to the following paragraphs for instructions to set up the temperature display and edit the setpoint on the controller.

Temperature Display Setup

The user can edit the display of water temperature on the controller to show the temperature as degrees Fahrenheit or Celsius. Use the input controls (Table 2) on the controller to set up the temperature display as follows:

1. Press the **Setup** button to enter the Setup mode. The Upper Display will show SET, and the Lower Display will show TUNING, which is the first Setup Group.
2. After the first Setup Group is displayed on the controller, press the **Setup** button again to cycle through the different Setup Groups. Continue to press the **Setup** button until DISPLY is shown on the Lower Display. This is the Display Setup Group.

NOTE	You can also use the **Up Arrow** and **Down Arrow** buttons to scroll through the Setup Groups.

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3. Once the Display Setup Group is selected, press the **Function** button. The Lower Display will show the first Function in the Display Setup Group, and the Upper Display will show the current value of the Function. Continue to press the **Function** button until the Lower Display shows UNITS, which is the Temperature Units Function.
4. Once the Temperature Units Function is selected, use the **Up Arrow** or **Down Arrow** button to select F for Fahrenheit, or C for Celsius.
5. Press the **Function** button to enter your selection into memory.
6. Press the **Lower Display** button to exit the Setup mode.

Setpoint Editing

The user edits the value of the setpoint on the temperature setpoint controller to set the desired water temperature level. Use the input controls (Table 2) on the controller to edit the setpoint as follows:

1. The Upper Display on the screen should show the outlet water temperature (Process Variable), and the lower display should show the characters SP (Setpoint) followed by the current value of the setpoint. If these are not shown, press the **Lower Display** button until the process variable and setpoint are shown.
2. Press the **Up Arrow** button to increase the value of the setpoint, and press the **Down Arrow** button to decrease the value of the setpoint.
3. The value entered will be stored in the setpoint after 30 seconds if no other key is pressed. To store the value immediately, press the Lower Display button again.

NOTE	If controller power is removed before the setpoint value is stored, the new setpoint value is lost and the previous setpoint value is used at power up.

NOTE	If the **MA-Reset** button is pressed accidentally while in automatic mode, the controller will switch to manual mode (Table 2). Verify that the display indicates automatic mode (Table 1). If the display indicates manual mode, press the **MA-Reset** button once to switch back to automatic mode.

Controller Monitoring Functions

One function of the controller is to monitor the temperature of the water as it leaves the heat exchanger on the HRM. The outlet water temperature value is stored in the Process Variable (PV). The characters "PV" on the screen of the controller indicate that the four-digit number in the upper display shows the value of the Process Variable.

The controller is also used to indicate alarm conditions. An over-temperature warning is indicated by Alarm 2 (ALM 2). ALM 2 is a pre-programmed alarm setpoint (not set by the user). When ALM 2 is lit on the screen, water temperature has exceeded the maximum limit for safe operation, and immediate action is necessary to lower the temperature to a manageable level.

The C200 MicroTurbine also reports the over-temperature warning as a user initiated fault. When the over-temperature alarm is tripped, the normally-closed contact of the ALM 2 relay opens, and the C200 MicroTurbine reads this signal at the designated fault discrete input on connector J12 of the JUCB.

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The displays on the controller contain other indicators that explain or clarify data on the screen, as well as convey important messages. Refer to the UDC2500 Universal Digital Controller Product Manual (51-52-25-127), and to the Troubleshooting paragraph below for more information.

HRM PREVENTIVE MAINTENANCE

The following paragraphs contain basic preventive maintenance procedures and steps that the user can perform on the HRM.

Performance Monitoring

When the HRM is new, record the performance data as described in the following steps:

1. Make sure that there is enough load on the MicroTurbine system so that the bypass assembly on the HRM is in full recovery mode.
2. Verify that the MicroTurbine performance is stable.
3. Record the outlet water temperature displayed on the temperature setpoint controller.
4. Record the power output from the MicroTurbine displayed on the MicroTurbine display panel.
5. Record the MicroTurbine's inlet air temperature, which can be read using the MicroTurbine display panel or Capstone Remote Monitoring System (CRMS).
6. Record the pressure gauge reading, if applicable.

The performance data for the HRM when it is new provides a basis of comparison that could determine, at a later time, the reason for a failure or a condition that requires corrective action. If the HRM shows a decline in performance, do the same steps described above and compare the current data with the data recorded when the HRM was new.

Refer to Troubleshooting below for possible causes of HRM failure or reduced performance.

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TROUBLESHOOTING

This section gives basic troubleshooting information that an operator can use to find the source of problems with the HRM. The following paragraphs contain possible causes of temperature control problems, and information about diagnostic messages on the temperature setpoint controller.

Troubleshooting Temperature Control Problems

The following paragraphs describe possible causes of electrical failures in the temperature controller, reduced heat transfer (low outlet temperature), and overly high outlet temperatures.

Temperature Controller Electrical Failures

Refer to the Temperature Controller System Wiring Diagram in the C200 Technical Reference (410070). Possible causes for the Temperature Controller System to fail or work improperly are as follows:

- ❑ The control panel fuses need to be replaced.
- ❑ Power from the MicroTurbine is missing or output is low. Refer to the C200 MicroTurbine User's Manual (400008) to troubleshooting the MicroTurbine.
- ❑ Contact your Capstone Authorized Service Provider (ASP) to check the temperature setpoint controller, modulating actuator, thermocouple, or system wiring for any electrical problems.

Reduced Heat Transfer

If the exit temperature of the water is lower than normal, it can mean reduced efficiency in the heat transfer process and a decrease in Btu/hr recovery. Possible causes of reduced heat transfer are as follows:

- ❑ The finned tubes have excessive contamination. Contact your Capstone ASP for more information.
- ❑ There are scale deposits in the tubes. Contact your Capstone ASP for more information.

Exit Water Temperature Too High

If the exit water temperature is too high or the HRM generates steam, check the following for possible causes:

- ❑ Water pressure going into the HRM is too low. The pump needs to be repaired or replaced.
- ❑ There is no or low water flow from the pump. The pump needs to be repaired or replaced.

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Diagnostic Messages

The temperature setpoint controller performs background tests to verify data and memory integrity. If there is a malfunction, the controller shows a diagnostic message on the lower display. In the case of more than one simultaneous malfunction, only the highest priority diagnostic message is displayed. Table 3 shows some example error messages. Refer to the UDC2500 Universal Digital Controller Product Manual (51-52-25-127) for more information.

Table 3. Diagnostic Messages

Prompt	Description	Corrective Action
EE FAIL	Unable to write to non-volatile memory.	Any time you change a parameter and it is not accepted you will see EE FAIL. Check accuracy of your input. Contact your Capstone ASP if unable to clear EE FAIL message.
IN1FL	Two consecutive failures of input 1 integration.	Indicates possible thermocouple or wiring fault. Contact your Capstone ASP.
CFGERR	Configuration errors: Low limit greater than high limit for PV, SP, Reset, or Output.	Refer to the UDC2500 Universal Digital Controller Product Manual (51-52-25-127) for configuration setup. Contact your Capstone ASP if unable to clear CFGERR message.
IN1RNG	Input 1 out of range.	Indicates possible thermocouple or wiring fault, or calibration error. Contact your Capstone ASP.
PV LIM	Process Variable out of range.	Indicates possible thermocouple or wiring fault, or calibration error. Contact your Capstone ASP.
FAILSF	The controller is in failsafe mode. This happens when the background test detects a memory, configuration, or calibration fault.	Contact your Capstone ASP.
LOCK	The lockout feature has been enabled.	Refer to the UDC2500 Universal Digital Controller Product Manual (51-52-25-127) to disable the lockout feature, or contact your Capstone ASP.
TCWARN	The thermocouple is starting to burn out. This error message will also appear if the resistance of the wires between the thermocouple and the controller is greater than 100 ohms.	Contact your Capstone ASP to check wiring and thermocouple.

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Prompt	Description	Corrective Action
TCFAIL	The thermocouple sensor is in imminent danger of burning out. This error message will also appear if the resistance of the wires between the thermocouple and the controller is greater than 180 ohms.	Contact your Capstone ASP to check wiring and thermocouple.
OUT1 FL	Current Output 1 is less than 3.5 mA. Indicates open circuit between controller and moculating actuator.	Contact your Capstone ASP to check wiring.

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CAPSTONE CONTACT INFORMATION

If questions arise regarding the C200 HRM, please contact Capstone for assistance and information.

Capstone Applications

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E-mail: applications@capstoneturbine.com

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E-mail: servicejapan@capstoneturbine.com

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